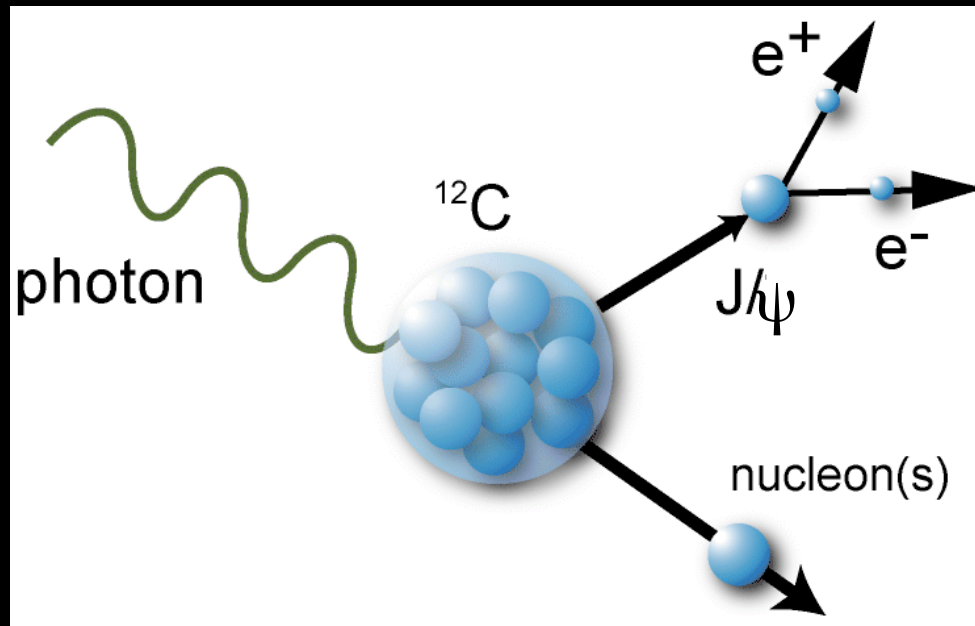
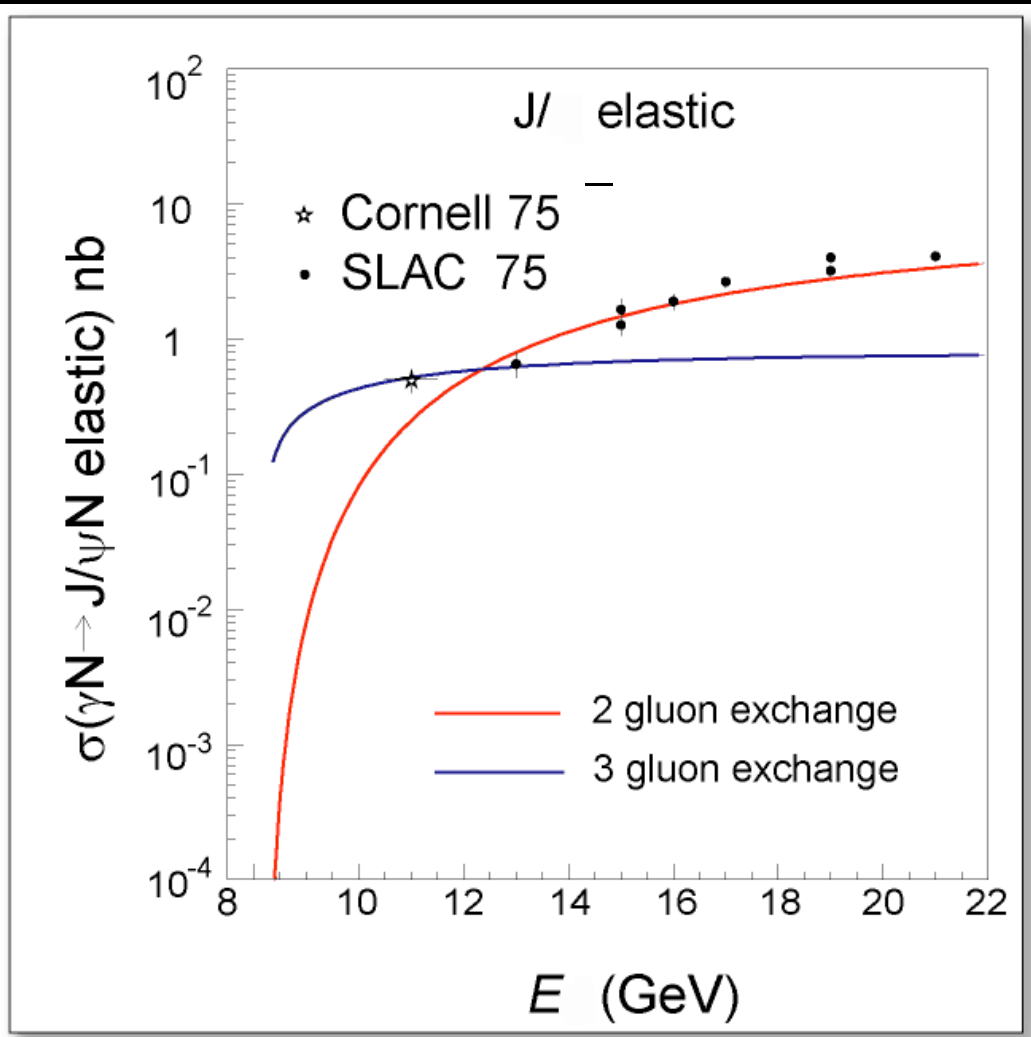


Sub-Threshold J/ψ Photoproduction



- Photoproduction Data
- Motivation
- Detector Response
- Cross Section
- Summary

Near Threshold Photoproduction



Cornell:

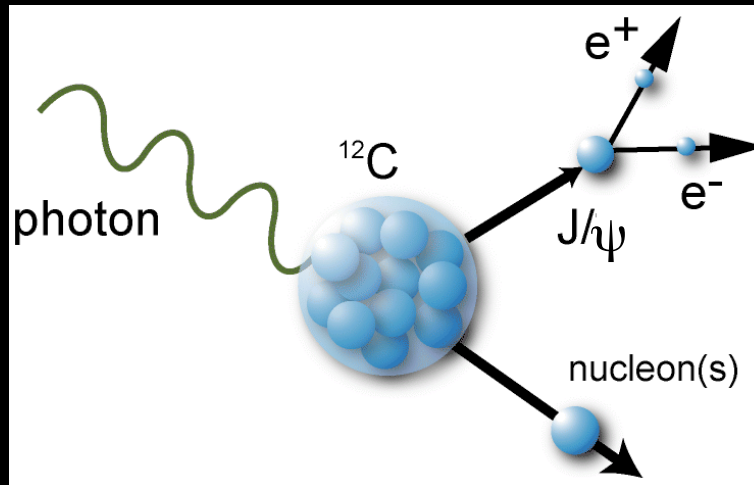
- 11.8 GeV endpoint
- Be target
- e^+e^- detected in lead-glass calorimeter.
- 470 events

SLAC:

- 21-13.5 GeV endpoint
- D_2 and H_2 targets

Cornell data indicate that the cross section flattens out near threshold.

Sub-Threshold J/ψ Definitions



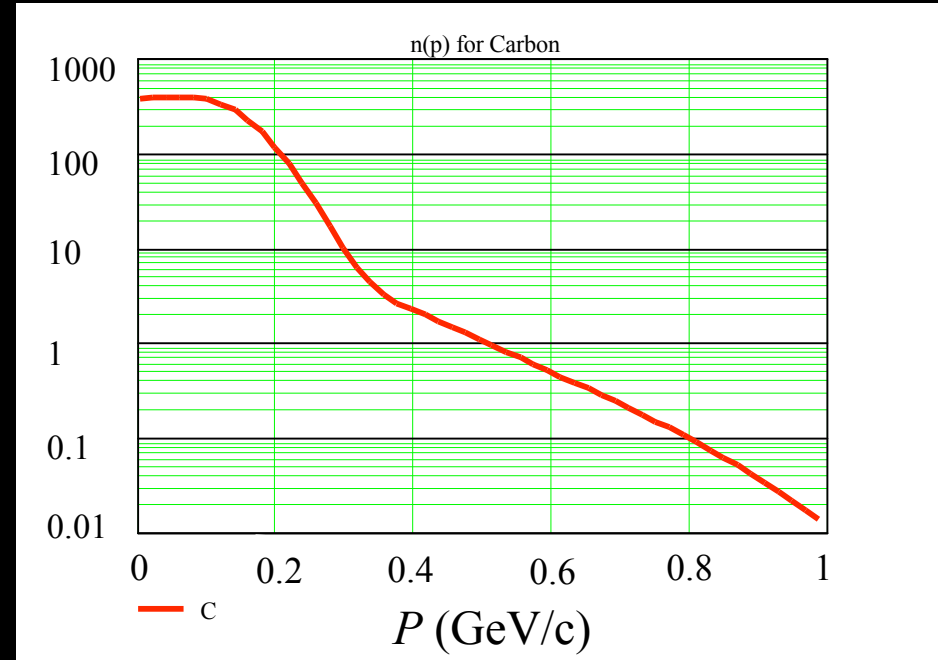
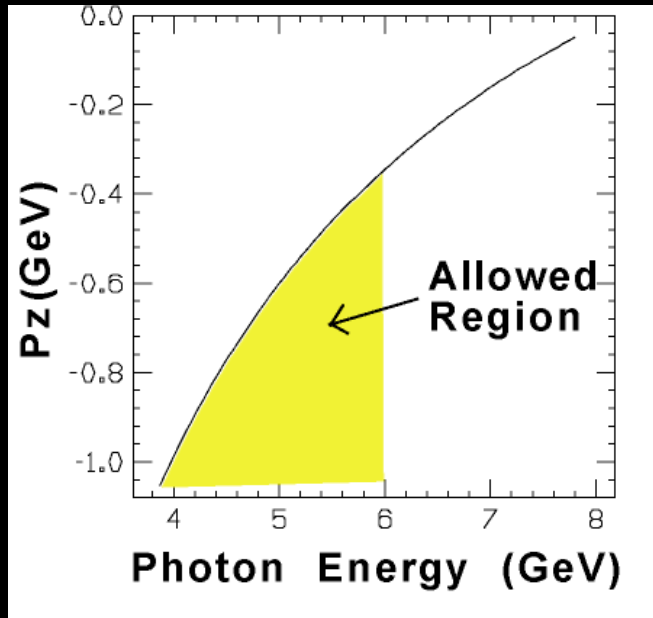
Mass 3.1 GeV

- Threshold for **free** nucleon is $k = 8.2$ GeV.
- Threshold for **moving** nucleon(s) in ^{12}C is 3.4 GeV.
- Thus 6 GeV at Jefferson Lab is sub-threshold to free nucleon
- Dominated by ^{12}C breakup to nucleon clusters.
- Coherent (^{12}C remains intact) suppressed by form factor.
- Inelastic (additional mesons) suppressed by phase space.

Motivation

- _ Study how nucleus differs from a loosely bound system of quasi-independent nucleons
- _ Study short range effects, including hidden color configurations, multi-nucleon correlations.
- _ Use heavy quarkonium
 - _ To ensure hard scale
 - _ Because charm quarks rare in nucleus, quark exchange mechanism suppressed.
- _ Open door to new area of study with first observation of heavy quarks at Jefferson Lab energies.

Why 6 GeV Optimal?



- Minimum nucleon momentum required for quasi-free production decreased with increasing energy.
- To emphasize region where short-range effects important, want $p_f > 0.35$ GeV or $k < 6$ GeV.

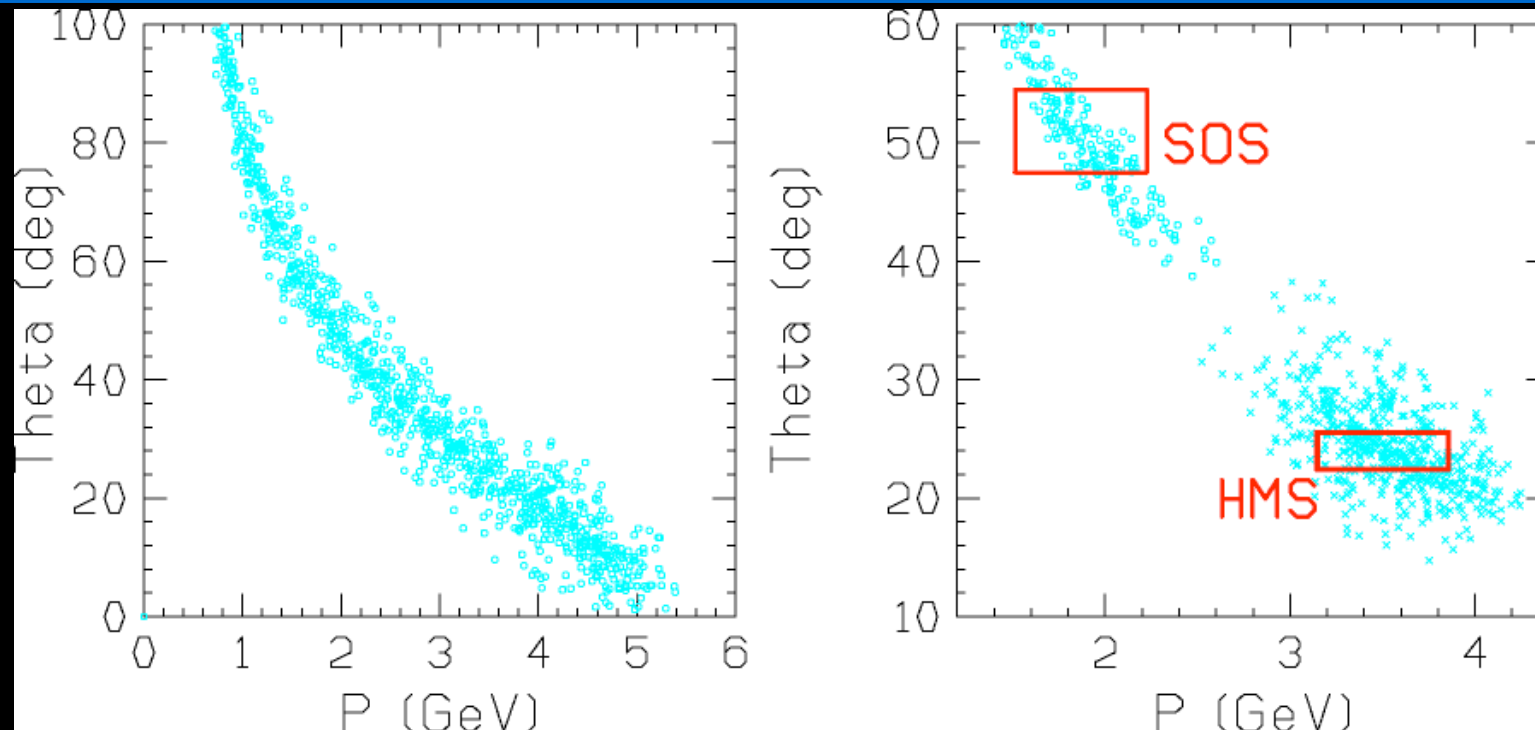
Sub-Threshold Cross Section Estimates

- _ Use simple Fermi-smearing model
- _ $d\sigma = \int d\sigma_0/dt \, n(p) \, d^3p dt$
- _ where integral limited to kinematically allowed region, $n(p)$ from $(e,e'p)$ data.
- _ Integrated over photon energy k using $1/k$ distribution.
- _ Use various function forms for $d\sigma_0/dt$, constrained to go through Corneel data point
- _ Estimate from Brodsky *et al.* is possible order of magnitude enhancement due to short range and hidden color effects (up to 20 pb/nucleon).

Experimental Plan

- _ Identify J/ψ from 6% B.R. to each of e^+e^- and $\mu^+\mu^-$
- _ Since rate and backgrounds uncertain, need good resolution (hence spectrometers) to ensure we see mass peak over backgrounds..
- _ Use 5.7 GeV, 60 μA electron beam passing through narrow 0.06 r.l. Carbon target. Limited by radiation dose.

Spectrometer Setting



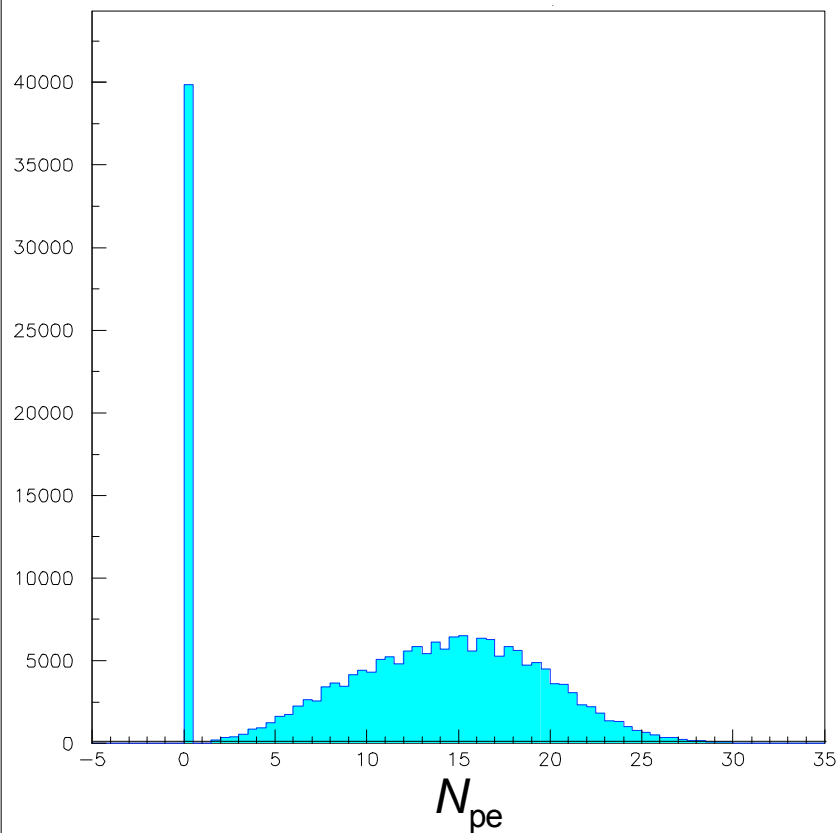
- _ Left panel shows all generated lepton pairs.
- _ Right panel shows settings for SOS and HMS acceptance: circles (crosses) are partners of leptons in HMS (SOS).

Detectors

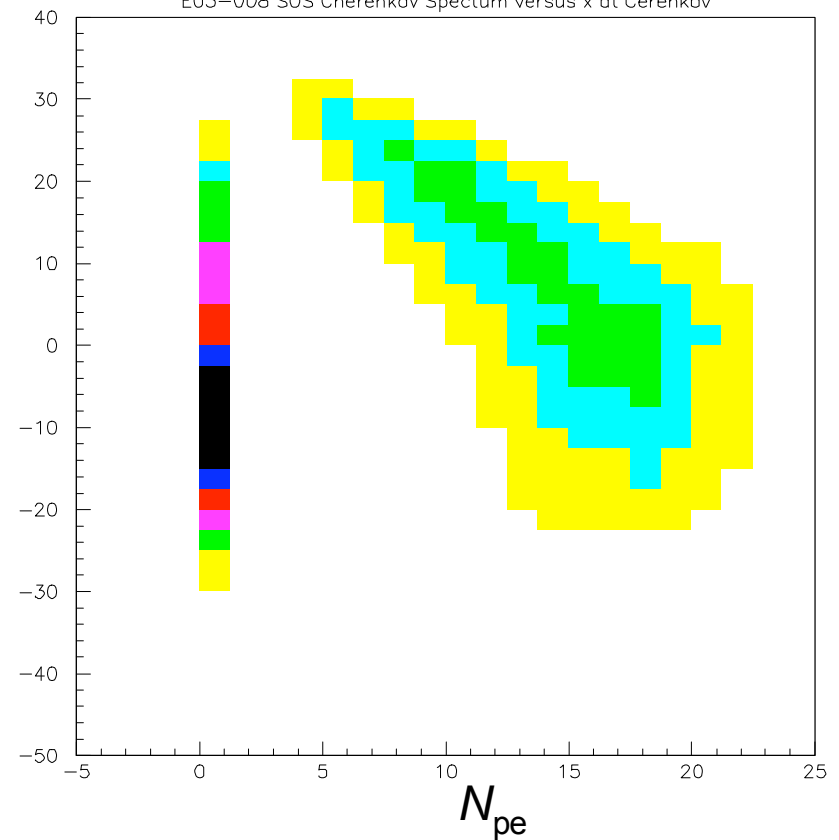
- Electron pairs use standard SOS, HMS detectors.
Expect negligible contamination from $(\pi^+\pi^-)$ and $(e^-\pi^+)$.
- Muons in HMS mainly identified by setting gas Cherenkov threshold to fire for muons but not pions.
- Also require minimum ionizing signal in all 4 layers of lead glass shower counter.
- Replaced existing Cherenkov with high pressure one.
- Overall for muons, got factor 200+ rejection of (π,π) events. Dominated by case where both pions decay to muons before detectors.

SOS Cherenkov Detector

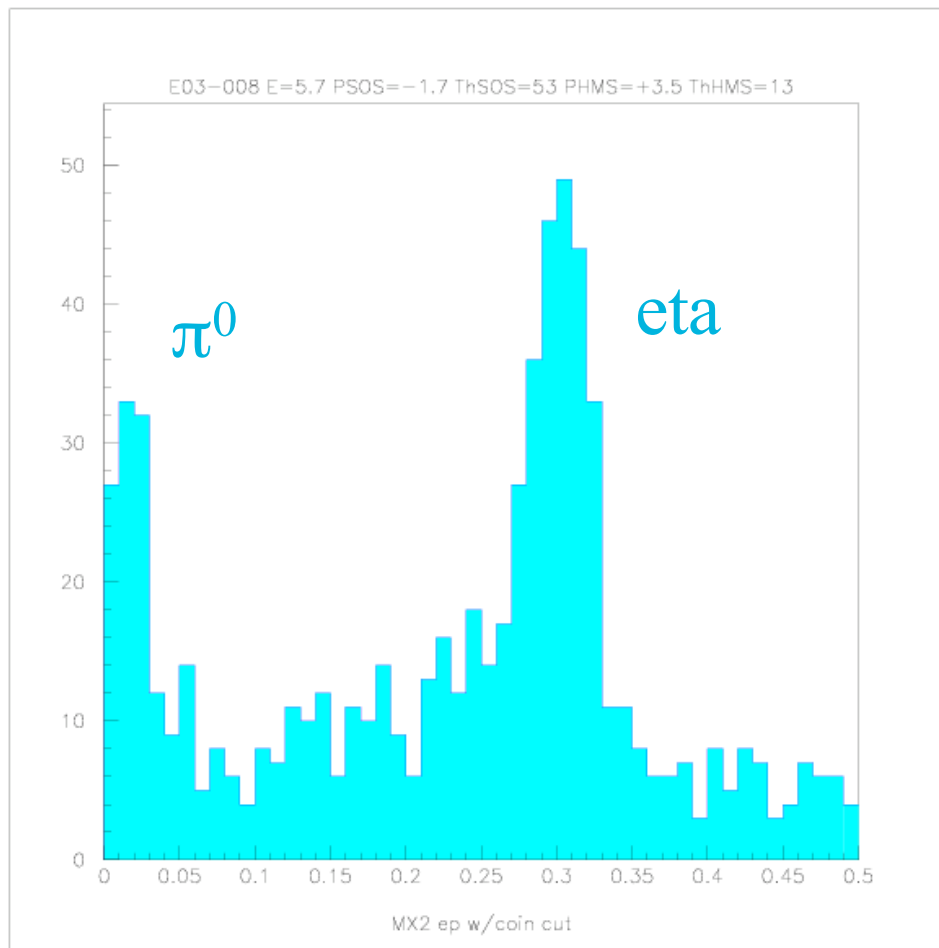
E03-008 SOS Cherenkov Spectrum



E03-008 SOS Cherenkov Spectrum versus x at Cherenkov

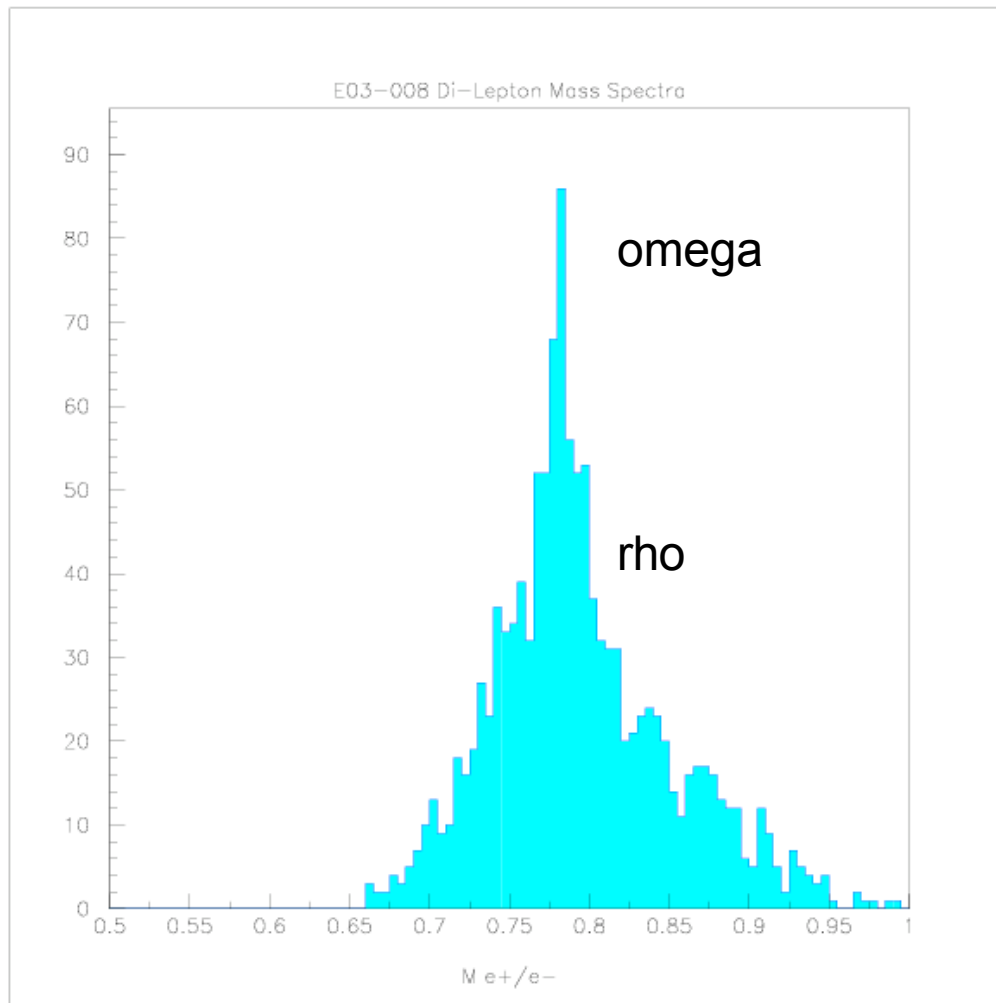


Calibration Runs



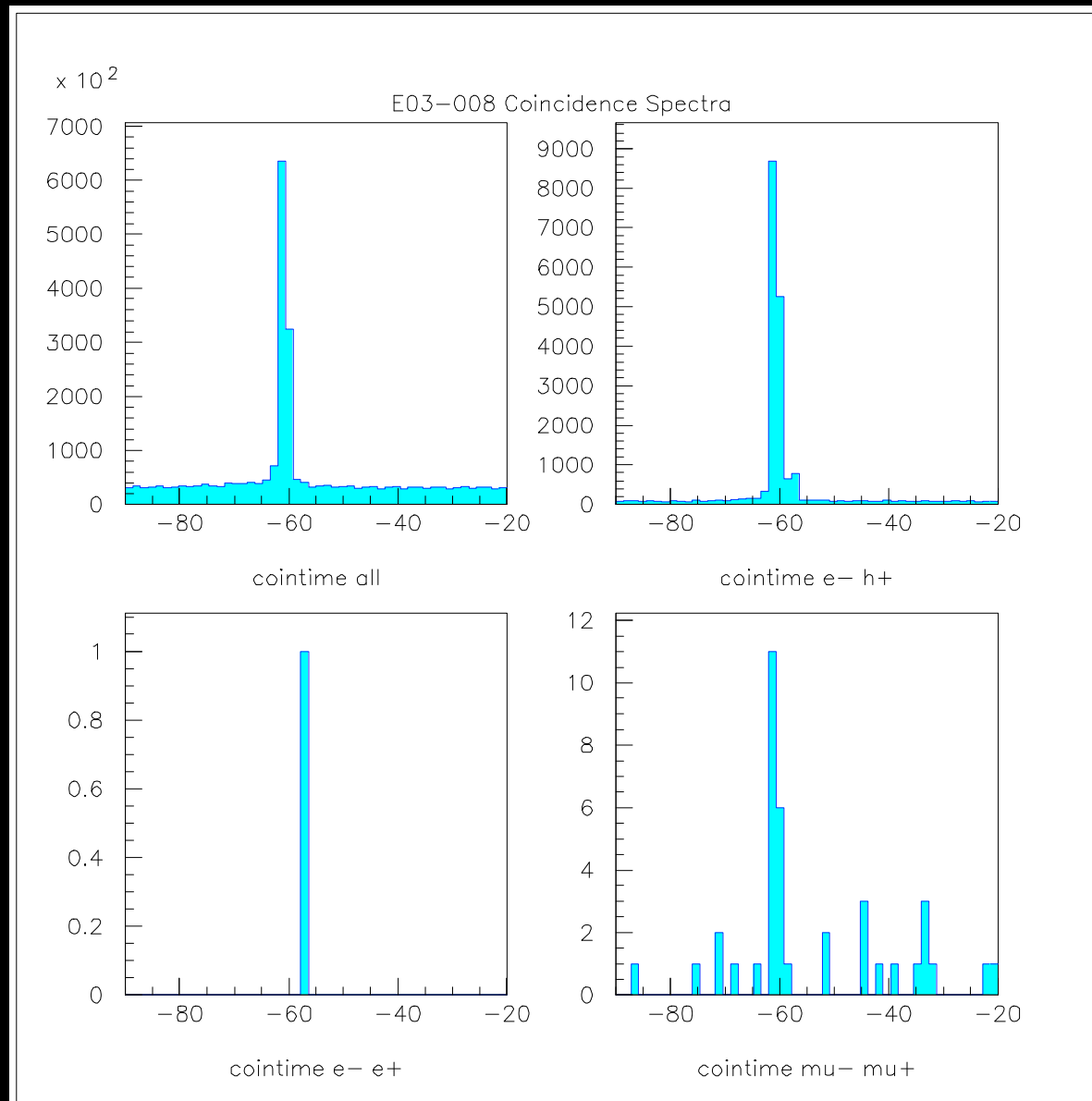
Using proton target with same settings as for J/ψ search, looked at missing mass of $p(e,e'p)X$. Clear peaks for π^0 and η are visible at correct locations, indicating spectrometers working as expected

Calibration Runs

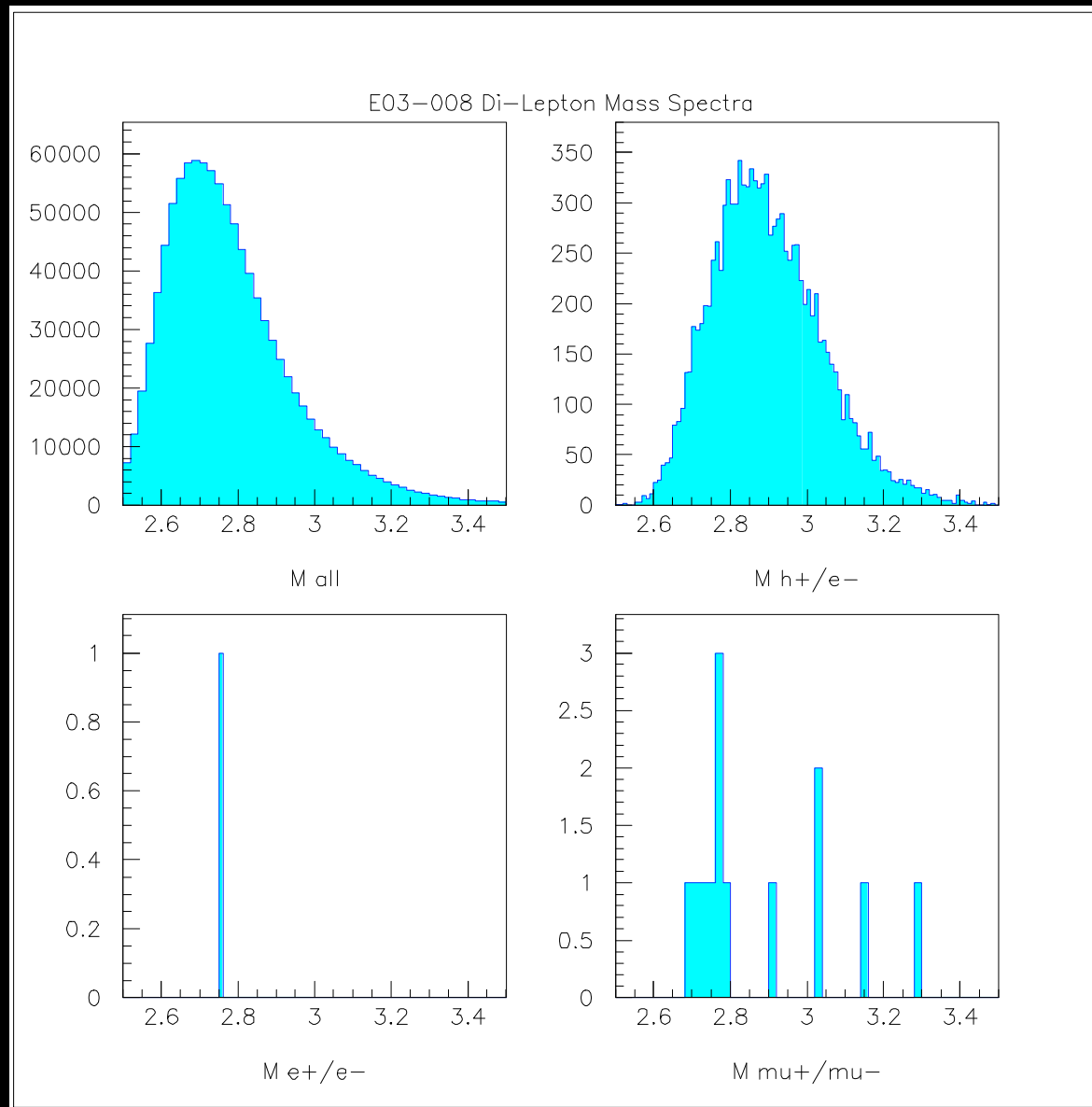


Set spectrometers to lower mass to find decays of $\rho(770)$ and $\omega(785)$ to e^+e^- . Both are clearly visible in mass spectrum

Coincidence Time



Invariant Mass



Cross Section Upper Limit

Each Model
has the form:

$$\frac{d}{dt} = a f(bt)$$

Model I: $f(bt) = e^{bt}$

Model II: $f(bt) = \frac{1}{(1 - bt)^4}$

Model III: $f(bt) = \frac{(1 - x)^2}{(1 - bt)^4}$

— For each model, used two different energies of the struck nucleon of momentum p_f

— E_1 : energy M (where M is nucleon mass)

— E_2 : energy $M - p_f^2/(2(12M))$

Determined the value of a that would correspond to 1 count for our luminosity.

Cross Section Upper Limit

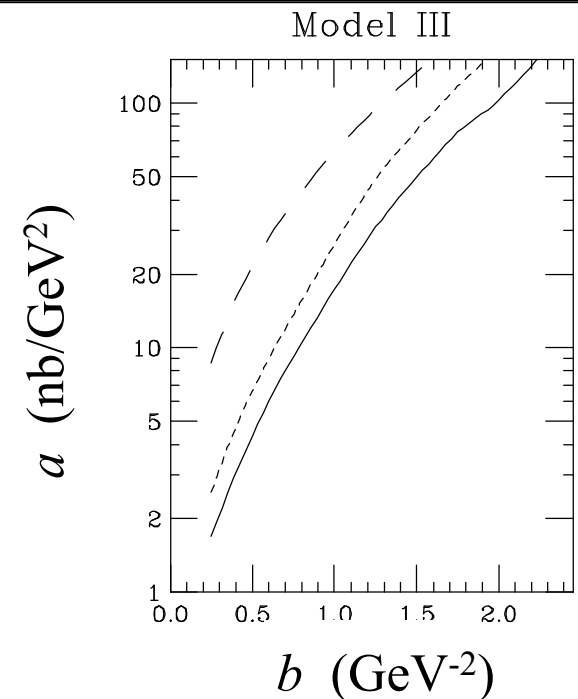
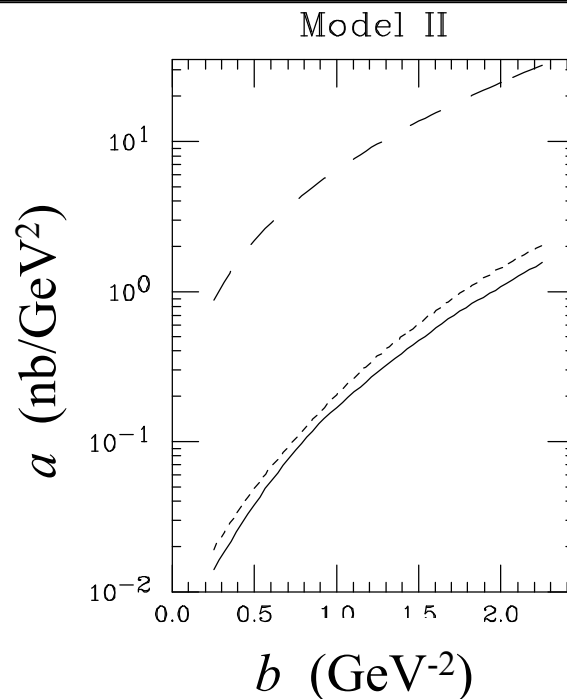
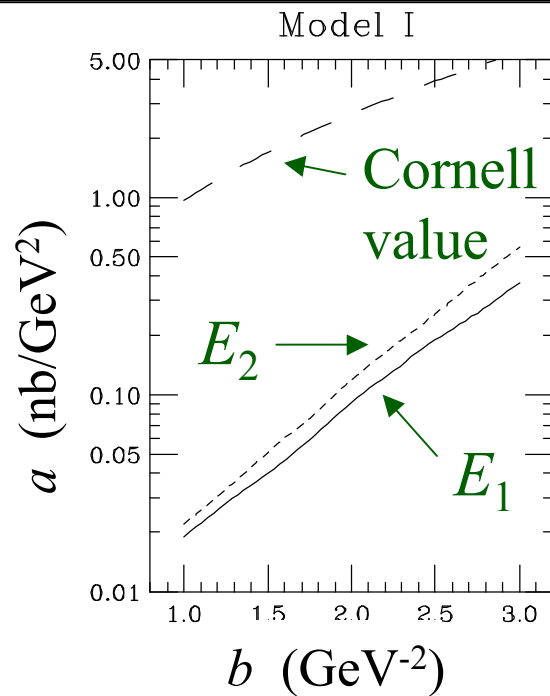
Each Model
has the form:

$$\frac{d\sigma}{dt} = a f(bt)$$

Model I: $f(bt) = e^{bt}$

Model II: $f(bt) = \frac{1}{(1 - bt)^4}$

Model III: $f(bt) = \frac{(1 - x)^2}{(1 - bt)^4}$



Summary

- No J/ψ decays observed
- Laget et al 3-gluon hypothesis ruled out
- Large hidden color configurations ruled out
- Data compatible with Cornell only in 2-gluon exchange model, and even then need $(1-x)^2$ factor as may be expected in some models.
- Rates will be low for Jlab at 11 GeV: need big detectors.